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REPLY: A Correspondence From a Maturing Discipline

In his letter to the editor of the *Journal of Medical Entomology,* Dr. Wells raises concerns regarding a proliferation of terms used to describe various subcomponents of the postmortem interval (PMI). These terms have arisen with the development of various models to understand the period of time that passes between death, colonization by insects, and the discovery of remains (Amendt et al. 2007, Villet and Amendt 2011, Tomberlin et al. 2011b). The model in Tomberlin et al. (2011b) was intended to facilitate research in carrion decomposition ecology, which informs the use of insects in forensics (Tomberlin et al. 2011a). Dr. Wells takes the issue with postcolonization interval (PCI) and a period of insect activity (PIA). We agree it is important to be explicit about and careful with their use. However, it is also worth noting that over the past few decades, forensic entomology has moved away from using PMI and toward more neutral terms like PIA and PCI. This change in terminology reflects a good-faith trend in the community to be transparent about what insect evidence provides to the legal system.

Forensic entomologists believe that insect evidence is informative of the timeline associated with a death. The probative value of forensic entomology information relies upon a correlation between what the insects tell us about a death and the actual PMI. However, forensic entomology is also concerned with the exact nature of such a correlation. These concerns lead to important research questions, such as what is the coefficient of correlation? Is it a linear relationship? What causes outliers?

Research is needed to address the concerns regarding the relationship between insect evidence and the PMI. In particular, research into the specific subcomponents of the PMI should seek to clarify the nature of the correlations between subcomponents of the PMI with total PMI. Validation studies are needed to determine whether (and under what conditions) succession and development data are informative of any of these terms, including the PMI. Unfortunately, at the moment there are few such studies in the literature (Schoenly et al. 2007, Tarone and Foran 2008, VanLaerhoven 2008, Tarone and Foran 2011, Núñez-Vázquez et al. 2013, Boehme et al. 2014).

Conceptual models should not be dismissed for semantic concerns regarding their application to forensic entomology (the use of any death interval term can be criticized to some degree). These models help drive research forward by dissecting the process of decomposition by insects in greater detail, even when the technical means to measure some of the concepts are not currently available. There have already been advances driven by these models (Matuszewski 2011, Ma et al. 2012, Mohr and Tomberlin 2014). However, as Dr. Wells notes, ultimately there is a need to translate these phases and intervals of decomposition into actual predictions in casework. At the core of forensic entomological practice is the prediction of insect specimen age or insect community age. Although these predictions may follow a development model (most commonly used in casework; Haskell 2007) or a succession model, they typically involve an interpretation of insect age as related to the timing of the death of an individual. To be of probative value, any prediction must be placed in the environmental and circumstantial context of the decedent. Regardless of the model used, this contextualization process requires making a number of assumptions about the relationship between insects and death.

"It almost goes without saying that one must make certain assumptions to reach any estimation of PMI" (Wells and Lamotte 2010). These assumptions include those noted by Dr. Wells in his letter, but can also include the presence or absence of myiasis or diapause (Wells and Lamotte 2010), accurate temperature data (Scala and Wallace 2010), accurate thermal summation models (Richards and Villet 2009, Higley and Haskell 2010), and the appropriateness of developmental data sets for estimating evidentiary specimen ages (Tarone and Foran 2006, Gallagher et al. 2010, Tarone et al. 2011). Any violations of assumptions lead to deviations between any death interval concept (regardless of its name) and an age prediction made by a practicing forensic entomologist. Forensic entomologists acknowledge the importance of understanding the consequences of violating such assumptions, and research is devoted to this area of inquiry, including the identification of previously unacknowledged assumptions. Researchers in the field appreciate the distinction between theoretical concepts and the inherent variation found when attempting predictions using real data.

Dr. Wells' concern regarding PCI is with the scale applied to the conceptual model in Tomberlin et al. (2011b), where the scale was not specified. Dr. Wells applies a community or guild-level interpretation of

PCI, which makes no differentiation in the constituent species' order of arrival (i.e., of all species on a body, PCI would only apply to the one that colonized the remains first). However, when the scale changes to the level of one species or individual specimens, PCI as described by Tomberlin et al. (2011b) appears to converge with the definition of the minimum PMI (mPMI) described by Wells and Lamotte (2010) using developmental data (which reflects a vague general recognition that, given certain assumptions, time passes between death and colonization by evidentiary insects). In this case, both terms are appropriate and language use becomes an issue of preference. However, it may be necessary to clarify the scale when using or discussing terms from Tomberlin et al. (2011b). Though few abandon PMI terminology, many connect PMI to PCI (and PIA) to link ecological concepts relevant to error in forensic entomology to the application in the field. We feel this approach is important in light of the Daubert et al. (1993) standard and the recent National Academy of Sciences (2009) report (Tomberlin et al. 2011a, b). Both PIA and PCI are insect-oriented and neutral regarding further interpretation of insect age as it relates to the interests of a trier of fact (who is often ultimately concerned with a PMI). More neutral terms should allow a jury to come to their decision in a manner that is less directed by the language used by our field.

This letter raises the need to be careful with numerous terms in the field. mPMI is now used in association with several conceptual frameworks. It appears to be used in the literature as a vague and uncited conservative catchall, it is equated with the PCI (Tomberlin et al. 2011b), and has an application-based definition given in Wells and Lamotte (2010). The last definition reflects general concerns that are dissected by more detailed conceptual frameworks (Villet and Amendt 2011, Tomberlin et al. 2011b). Similarly, PIA is used with different definitions by different colleagues to reflect various application and ecologically oriented concepts (see Amendt et al. [2007] and Villet and Amendt [2011] in addition to Campobasso et al. [2005] and Tomberlin et al. [2011b]). Given the multiple meanings associated with such terms, it is appropriate that we all be explicit in our intent when using them in the future. We encourage that the use of all of these terms be cited or clearly defined to allow readers and reviewers to specifically understand the intended meaning of the term.

We feel that it would be more productive to see empirical and theoretical tests of such issues (when possible) in lieu of letters to the editor; research findings will be more constructive in addressing many of the issues related to this conversation. The temporal distinction between PMI and PCI (or PIA) may be trivial or extremely large, but at the moment there is little evidence to suggest how often either scenario applies to casework. Workshops that strive to develop a consensus on the use of certain terms may also be appropriate. It is illogical to dismiss concepts that expand our knowledge and help a developing field to mature, but we welcome the opportunity to refine and expand our discussion regarding how to more effectively talk about what forensic entomologists do in research and in practice.

Now is an exciting time to be a forensic entomologist. The field has grown considerably in recent years, and with that growth has come a new generation of innovative research. Findings likely to be generated in coming years will undoubtedly lead to a better understanding of the sources of error associated with the predictions that are made with insect evidence and should lead to greater accuracy and precision. Such accomplishments will strengthen the field of forensic entomology both in and out of the courts.

For those interested, Rivers and Dahlem (2014) independently addressed concerns Dr. Wells proposed in his letter in a very clear and concise chapter.

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REPLY: Commentary on Letter to the Editor From Jeffrey Wells

We appreciate the opportunity to respond to Dr. Wells' letter, although it appears that he does not take issue with our work (indeed Dr. Wells is a coauthor on Campobasso et al. [2005]). However, as forensic pathologists, we would like to express our point of view on the definitions of terms like postcolonization interval (PCI) and period of insect activity (PIA) concerning the estimation of postmortem interval (PMI) based on the entomological evidence.

The letter to the Editor by Dr. Wells follows a previous oral presentation the same author gave in Coimbra at the last annual European Association for Forensic Entomology (EAFE) meeting in April 2013 (http://www.eafe.org/Meeting_Coimbra.htm). Dr. Wells raises several criticisms to the practical implications of PCI and PIA as defined by Tomberlin et al. (2011) to guide basic research. In this regard, we agree with his final suggestion that no forensic entomologist should use those definitions unless she or he has fully explained, in the report, the exact meaning.

Although Campobasso et al. (2005) did not provide an explicit definition for PIA, the way in which those authors used the terms makes it clear that the phrase corresponded to the age of the oldest larva collected from the corpse. It was, therefore, a development-based minimum PMI (PMImin), which refers to an event that occurred after the onset of decomposition. Seen in that light, some previous publications also used the term PIA (Catts and Goff 1992, Goff 1993, Greenberg 2001) without providing an explicit definition but with the implicit meaning of duration or interval after colonization. In this regard, a protocol document for best practice in forensic entomology (Amendt et al.